ECE220

Lecture x0012 - 10/29/24

Linked lists - stacks & queues

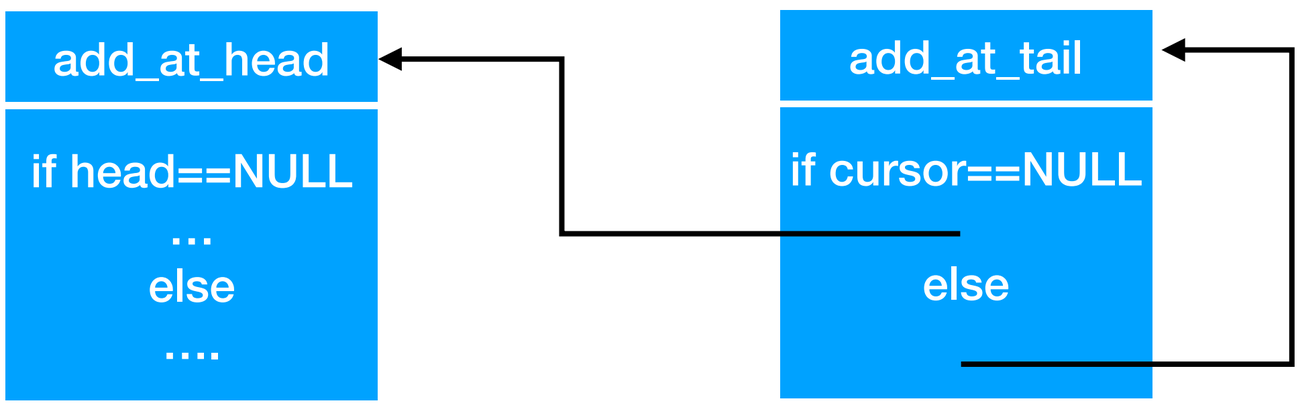
Recap

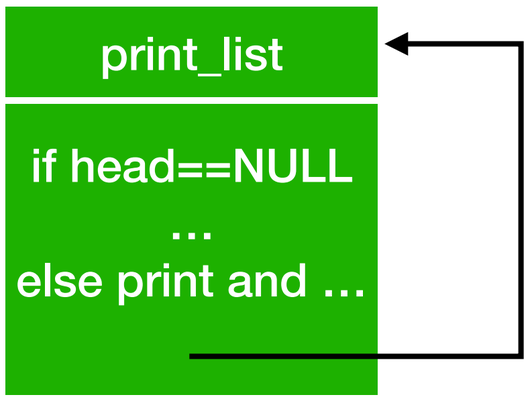
- Last week - Tuesday
  - Dynamic memory allocation: `malloc, calloc, realloc, free`
  - Two dimensional arrays
  - Reading/writing `structs` to files
  - Examples
- Last week - Thursday
  - Linked lists
  - Traversal
  - Insertion - head, tail, sorted
  - Deletion - head, tail, middle

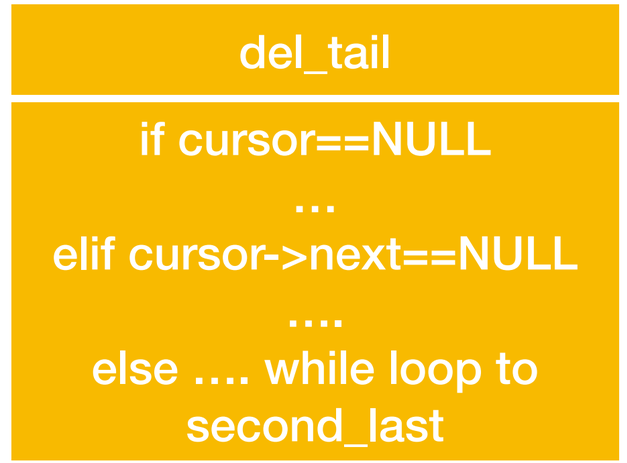
Reminders

- **Exam on 10/31**, study study!
  - Study material has been posted
  - Lectures 7 through 15 inclusive
  - HKN review session material is available
- About the exam
  - Paper-format (same as last time)
  - Four questions
    - Arrays & recursion (in C)
    - C2LC3 conversion, concept questions

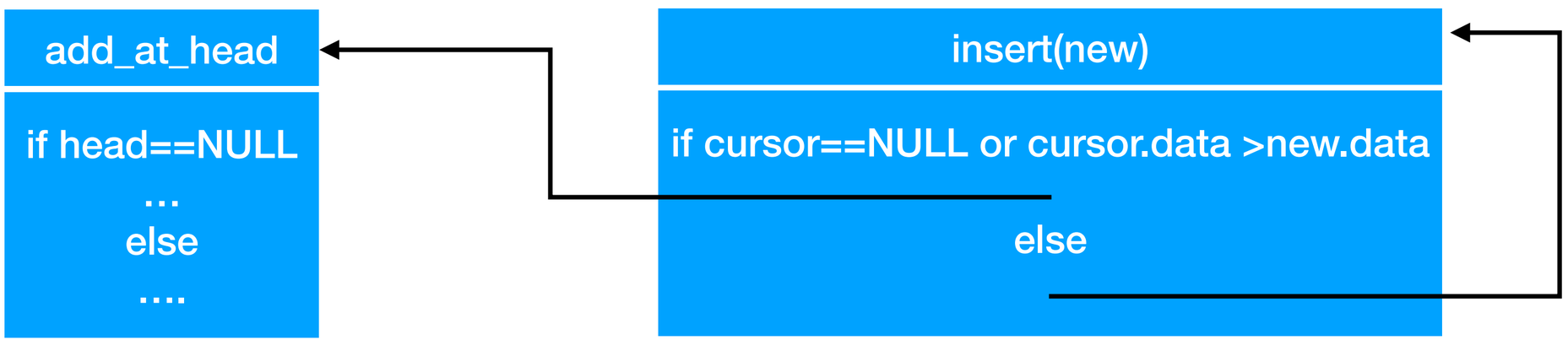
Review - singly linked lists (plain)

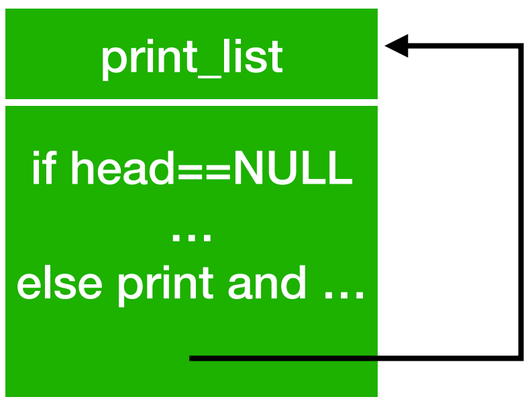






Review - singly linked lists (sorted)





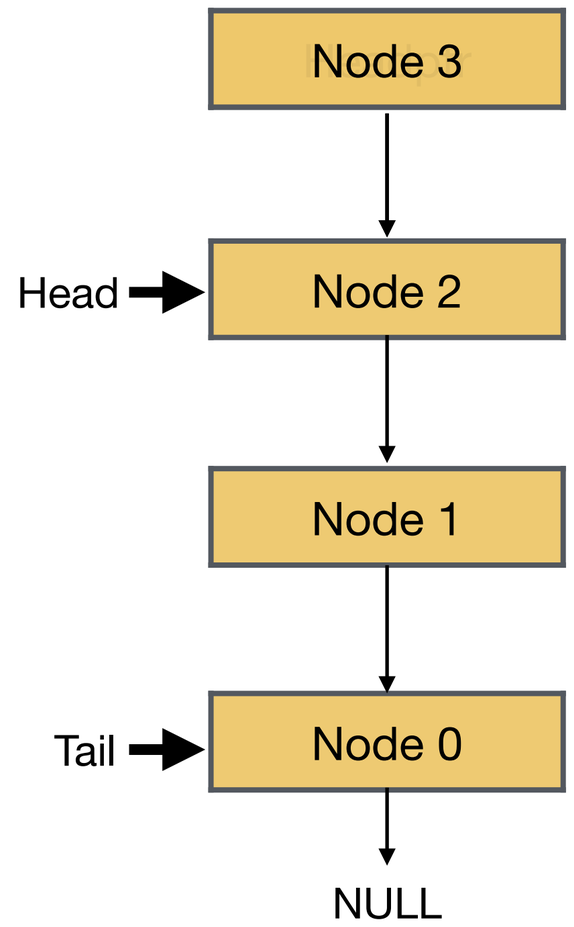
del_node(key)

```
init prev, current=headptr

while (current != NULL){
If current.data == key; break
….}
… //book keeping
```

Stack using linked lists

- First item in is the last item out - FILO
- Two operations for data movement: Push & Pop
- Stack top ~ head pointer/head
- Push ~ add at head
- Pop ~ remove from head
  - Need to give popped value to caller



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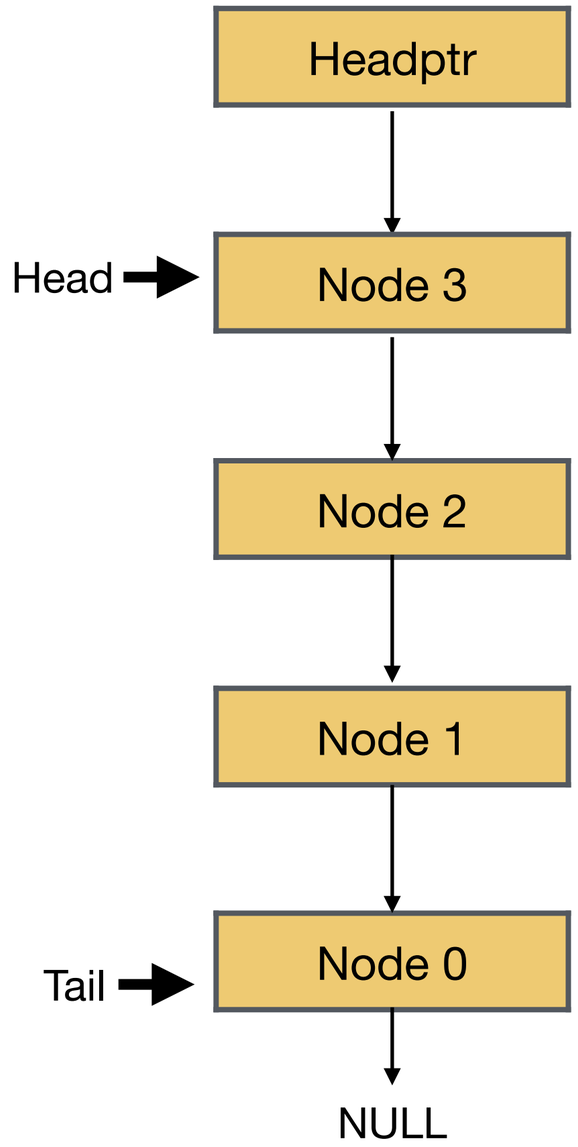


Stack push using linked lists

- Suppose we want to **push a node onto stack.**

- What needs to be done?
  - New node should point to current head.
  - Current head should be updated to new node.

Same as insert at head

```
void push(node **cursor, node *new){

  node* temp=(node*) malloc(sizeof(node));
  temp->name=new->name;
  temp->byear=new->byear;
  temp->next=new->next;

  if (cursor == NULL)
      *cursor = temp;
  else{
    temp->next = *cursor;
    *cursor = temp;
  }
}
```

Stack pop using linked lists

- To **pop** a node from stack, we have to delete node from head
  - Save the data of head node
  - Make a copy of the head pointer
  - Shift the head pointer to its next item
  - Call `free` on a copy of the head pointer
  - Return the popped/saved node to caller

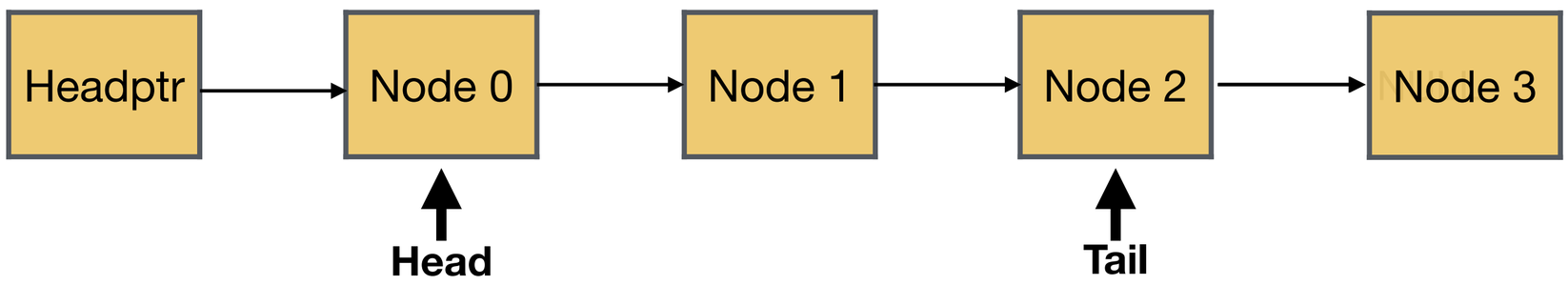
Similar to delete at head

```
node * pop(node **headptr){
  if (*headptr==NULL)
    return NULL;
  else{
    node * new=(node*) malloc(sizeof(node));
    new->name=(*headptr)->name;
    new->byear=(*headptr)->byear;
    new->next = NULL;

    node *old_head = *headptr;
    *headptr = (*headptr)->next;
    free(old_head);

    return new;
  }
}
```

Queue using linked lists

- First item in is the first item out - FIFO
- Two operations for data movement: enqueue & dequeue
  - Dequeued item must be available for use by caller

Enqueue



Queue using linked lists

- First item in is the first item out - FIFO
- Two operations for data movement: enqueue & dequeue
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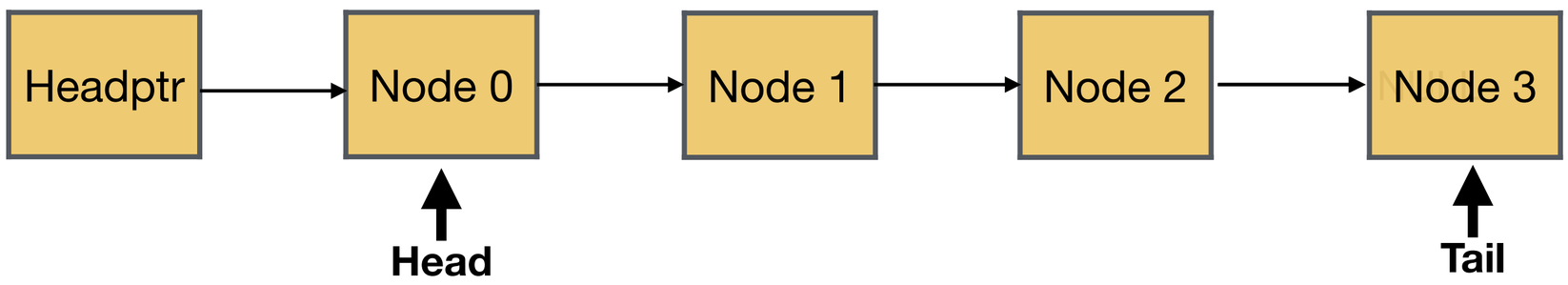
Dequeue

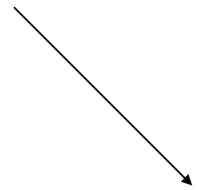


Enqueue using linked lists

- To add (enqueue) a **node** to a queue
- We need to first find the tail

How? The only element in the list whose next is NULL is the tail element.

```
void enqueue(node **cursor, node *new){
  if (*cursor == NULL){
    node * temp = (node *) malloc(sizeof(node));
    temp->name = new->name;
    temp->byear = new->byear;
    temp->next = new->next;
    *cursor = temp;
  }
  else
    enqueue(&(*cursor)->next, new);
}
```



Same as insert at tail

Dequeue using linked lists

- To delete (dequeue) a **node** from the queue
  - If head empty do nothing, else,
    - Save copy of current head
    - Advance head pointer and free the memory used by old head
    - Pass/return dequeued item to caller

```
node * dequeue(node **headptr){
  if (*headptr==NULL)
    return NULL;
  else{
    node* new=(node*)
malloc(sizeof(node));
     new->name=(*headptr)->name;
     new->byear=(*headptr)->byear;

     node *old_head = *headptr;
     *headptr = (*headptr)->next;
     free(old_head);

     return new;
  }
}
```

Same as delete at head!

Exercise(s)

- Given a *sorted* linked list, implement binary search on the list

```
node * binary_search(*headptr, char * key)
```

  - Return a NULL pointer if the element is not found
  - Otherwise return a pointer to the element.

- Hint: Write a function to get the middle element in a linked list

How do you find the middle element in a linked list?

Finding middle of a linked list

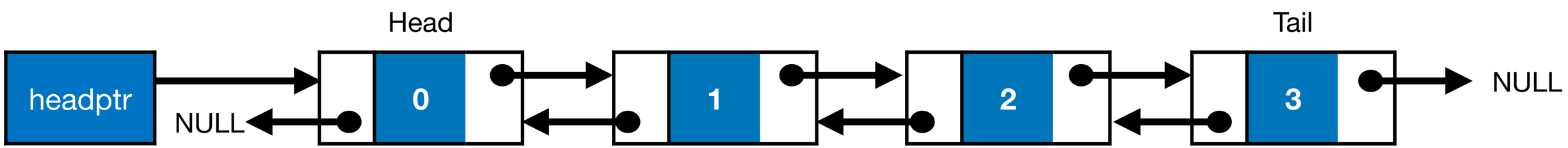
```c
#include <stdio.h>

int main(void){
  int i, target, j;
  printf("Enter a target number:\t");
  scanf("%d", &target);
  for (j=0, i=0; j<target; i++, j++)
    j++;
  printf("Midway to target is %d", i);
}
```

Exercise(s) - do at home!

- Given two ***sorted*** linked lists write a function that takes the two head pointers and returns a pointer to a ***merged*** list
- Sort order **must be maintained.** Basic idea …
  - Traverse both lists until one of them ends, then copy over the remaining list
  - During traversal add new nodes in sorted order

Doubly linked list



*A **doubly linked** list maintains a pointer to both the previous as well as the next element.*

- Advantages:
  - Allows backward and forward traversal
  - Easier to delete a node - why?
- Disadvantages
  - Takes up more memory.
  - Increased bookkeeping, therefore performance overhead

Doubly linked lists

- First there will be a change to the struct definition
- Need to modify insertion/deletion functions so that prev and next are maintained.
  - Insert at head
  - Insert at tail
  - …

```
typedef struct person{
  char *name;
  unsigned int byear;
  struct person *next;
  struct person *prev;
}node;
```

More on this when we talk about Trees!